

*Determination of the Hydrogen Specification
for Transportation Applications*

ROLE OF THE USFCC

TRANSPORTATION WORKING GROUP

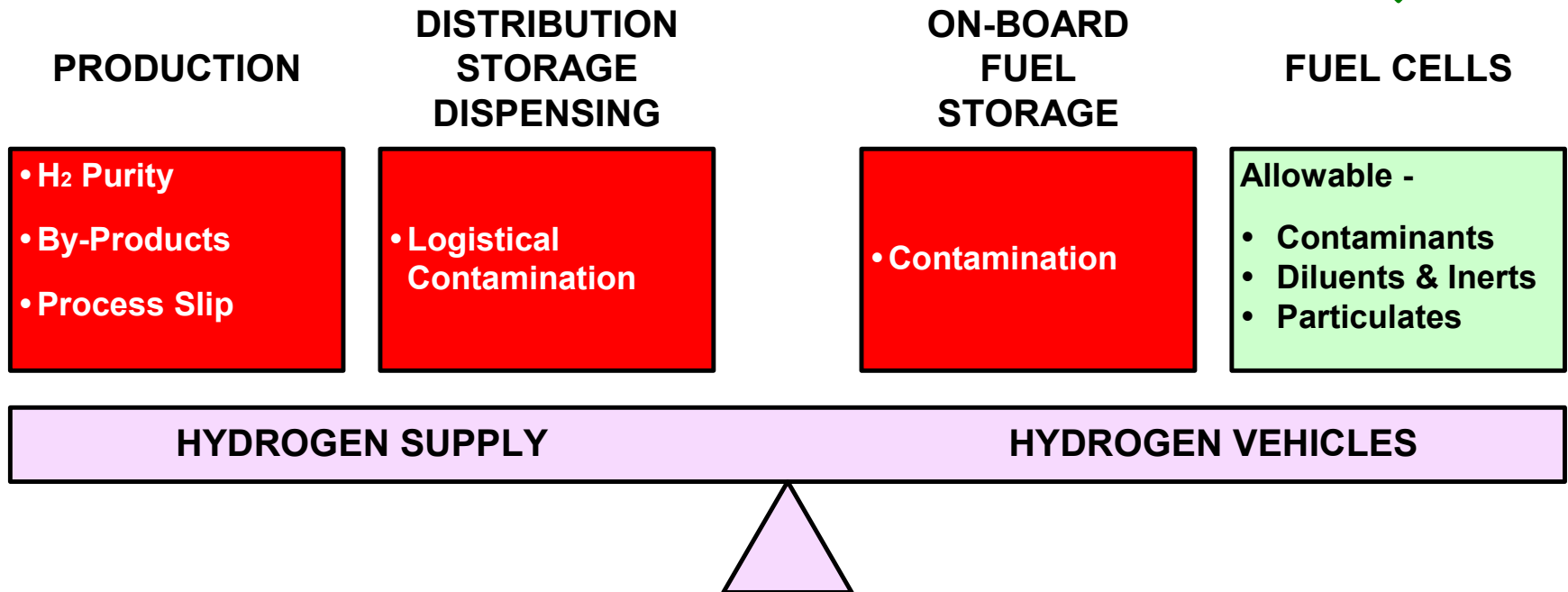
USFCC-0004

2004 April 23

Elements of Consideration when Specifying Hydrogen Purity

Finding a Cost Effective Solution for Transportation


Focus of USFCC Contribution
is impact on fuel cell stack



Need to strike a balance between supply costs and vehicle requirements.

Categories of Hydrogen Impurities & Stakeholders

Types of Impurities of Interest	Stakeholders
• Catalytic / Cell Contaminants	Fuel Cell Manufacturers
• Diluents and inerts	System Integrators
• Particles	Vehicle Manufacturers



Key Activities from Perspective of USFCC

USFCC
(Expertise in Fuel Cells)

Develop Test Protocol, Matrix, and Test Plan(s) to measure impact of impurities on fuel cells

Update protocol for technology changes

Interpret and Publish Results

Research

Perform fundamental fuel cell tests to evaluate effects of impurities

Postulate and validate the mechanism causing the impact on the fuel cell

Assess impact of impurities on storage media

Assess implications of H₂ purity on H₂ infrastructure

Assess experiences from validation & demonstration projects

Coordinate information and analyses with international experts (SDO's and professional groups)

Define Terminology

Identify impurities of concern

Identify methods for detection of impurities

Develop and iterate evolving H₂ purity guidelines leading to a proposed standard for commercial H₂ fuel purity

Integration with Vehicles,
Storage & Distribution,
and Hydrogen Producer
Stakeholders

Development of
Guidelines and
Standards

2004

2010

Ready for Commercialization

USFCC Role and Responsibilities

- **Propose Fundamental Cell Testing (target 12/04)**
 - **Recommend single cell test design and operating parameters (see Table 1)**
 - **Identify contaminants (see Table 2)**
 - **Recommend test protocol**
 - **Recommend test matrix**
- **Evaluate Test Information (FY04 – FY08)**
 - **Develop understanding of mechanisms causing adverse fuel cell impact**
 - **Recommend reconciliation of diverse test results**
 - **Identify contaminants with impacts resulting from long-term and short-term exposure**
- **Revise Test Protocol for Evolving Learnings & New Materials(FY04-FY08)**
- **Publish findings on a regular basis (annual)**

Example of Expected Elements in Proposed Single Cell Test Design and Operating Parameters

Parameter	Minimum or Typical Value	Maximum
Operating Time <ul style="list-style-type: none"> • Continuous operation • Life 		Up to 10 hours 5000 Hours
Current Density	250 ma/cm ² (average)	1000 ma/cm ² (peak)
Catalyst Loading <ul style="list-style-type: none"> • Anode • Cathode 	<i>Based on 0.2g/kW:</i> 0.05 mg/cm ² 0.05 mg/cm ²	0.3 mg/cm ² (Pt or Pt-Ru) 0.3 mg/cm ² (Pt)
External Hydrogen Utilization	Over 99%	Over 99% desired
Temperature	Subfreezing	80 degC
Pressure	Atmospheric	2.5 Atmospheres (gauge)
Humidifier	As specified by manufacturer	

Example of Target Contaminants

Impurity	Comments	Impurity Effect		Impurity Property		
		Inert	Contaminant	Condensable	Non-condensable	Particulate
Water (H ₂ O)	Set by tank mfrs and VMs	X		X		
Argon (Ar)		X			X	
Helium (He)		X			X	
Nitrogen (N ₂)		X			X	
Ammonia (NH ₃)			X		X	
Carbon Dioxide (CO ₂)		X	X		X	
Carbon Monoxide (CO)			X		X	
Formic Acid (HCOOH)			X		X	
Formaldehyde (HCHO)			X		X	
Hydrocarbons:						
1) Methane (CH ₄)		X			X	
2) Non-methane alkanes	C ₂ H ₆ , C ₃ H ₈ , etc.		X		X	
3) Olefines			X		X	
4) Aromatics			X		X	
Sulfur (Total all compounds)	H ₂ S, COS, and SO ₂ (?)		X		X	
K ⁺	In water from electrolyzers		X			
Na ⁺	In water from NaBH ₄		X			
Chromium (Cr)	Set by tank mfrs and VMs		X			X
Iron (Fe)	Set by tank mfrs and VMs		X			X
Mercury	From Chlor-Alkali		X	?	?	
Nickel (Ni)	Set by tank mfrs and VMs		X			X
Oxygen	Set by tank mfrs and VMs		X			X

Example of Inputs for Contaminant Testing

•Example Elements of a Recommended Test Protocol

- Overview of test program
- Quality control criteria for repeatable and reproducible results
 - Definition of components, measurement accuracy and calibration
- Reporting of information
 - Type of information, Accuracy of information

•Example Elements of a Recommended Test Matrix

- Grouping of probable impurities by common families
- Variations to be tested
 - Contaminant amount
 - Contaminant levels, exposure duration, flow rates
 - Pressure; total and partial
 - Temperature
- Interactions between contaminants

•Example Elements of a Recommended Test Plan

- Overview of test plan
- Requirements
 - Apparatus, measurements, tolerances
- Baseline test conditions and operating parameters
- Variations in physical exposure conditions (temperature, pressure, relative humidity)
- General test procedures and diagnostics

SUMMARY

Role of USFCC is to Apply Expertise to:

- **Recommending a robust test protocol for use by diverse organizations to evaluate impacts of hydrogen impurities on fuel cells**
- **Evaluating test information to assess the mechanism by which hydrogen impurities impact fuel cells**
- **Publishing findings and Advising Standards Development Organizations**

US Fuel Cell Council

1625 K Street, NW, Suite 725

Washington, DC 20006

202-293-5500

www.usfcc.com